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THREADED CONNECTION FOR EXPANDABLE TUBULARS

Cross Reference To Related Applications

[001] The present application is the National Stage patent application for PCT patent application serial number PCT/US2003/025716, attorney docket number 25791.129.02, filed on 08/18/2003, which claimed the benefit of the filing dates of (1) U.S. provisional patent application serial no. 60/412,371, attorney docket no 25791.129, filed on 9/20/2002, the disclosures of which are incorporated herein by reference.

[002] The present application is a continuation-in-part of U.S. utility patent application serial number _____, attorney docket number 25791.127.___, filed on _____, which is a National Stage patent application of PCT patent application serial number PCT/2003/025707, attorney docket number 25791.127.02, filed on 8/18/2003, which claimed the benefit of the filing dates of U.S. provisional patent application serial no. 60/412196, attorney docket no 25791.127, filed on 9/20/2002, which was a continuation-in-part of U.S. utility patent application serial number _____, attorney docket number 25791.120.___, filed on _____, which is a National Stage patent application of PCT patent application serial number PCT/US2003/025676, attorney docket number 25791.120.02, filed on 08/18/2003, which claimed the benefit of the filing dates of U.S. provisional patent application serial no. 60/405,394, attorney docket no 25791.120, filed on 8/23/2002, which was a continuation-in-part of U.S. utility patent application serial number _____, attorney docket number 25791.119.___, filed on _____, which is a National Stage patent application of PCT patent application serial number PCT/US2003/025677, attorney docket number 25791.119.02, filed on 08/18/2003, which claimed the benefit of the filing dates of U.S. provisional patent application serial no. 60/405,610 attorney docket no 25791.119, filed on 8/23/2002, which was a continuation-in-part of U.S. utility patent application serial number 10/_____, attorney docket number 25791.106.05, filed on 1/19/2005, which was a continuation-in-part of U.S. utility patent application serial number 10/511,410, attorney docket number 25791.101.05, filed on 10/14/2004 which claimed the benefit of the filing date of U.S. provisional patent application serial number 60/372,632, attorney docket number 25791.101, filed on 4/15/2002, which was a continuation-in-part of U.S. utility patent application serial number 10/510,966, attorney docket number 25791.93.05, filed on 10/12/2004, which claimed the benefit of the filing date of U.S. provisional patent application serial number 60/372,048, attorney docket number 25791.93, filed on 4/12/2002, which was a continuation-in-part of U.S. utility patent application serial number 10/500,745, attorney docket number 25791.92.05, filed on 7/6/2004, which claimed the benefit of the filing date of U.S. provisional patent application serial number 10/500,745, attorney docket number 25791.92, filed on 12/10/2002.

[003] The present application is related to the following: (1) U.S. patent application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, (2) U.S. patent application serial no. 09/510,913, attorney docket no. 25791.7.02, filed on 2/23/2000, (3) U.S. patent application serial no. 09/502,350, attorney docket no. 25791.8.02, filed on 2/10/2000, (4) U.S. patent no. 6,328,113, (5) U.S. patent application serial no. 09/523,460, attorney docket no. 25791.11.02, filed on 3/10/2000, (6) U.S. patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, (7) U.S. patent application serial no. 09/511,941, attorney docket no. 25791.16.02, filed on 2/24/2000, (8) U.S. patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, (9) U.S. patent application serial no. 09/559,122, attorney docket no. 25791.23.02, filed on 4/26/2000, (10) PCT patent application serial no. PCT/US00/18635, attorney docket no. 25791.25.02, filed on 7/9/2000, (11) U.S. provisional patent application serial no. 60/162,671, attorney docket no. 25791.27, filed on 11/1/1999, (12) U.S. provisional patent application serial no. 60/154,047, attorney docket no. 25791.29, filed on 9/16/1999, (13) U.S. provisional patent application serial no. 60/159,082, attorney docket no. 25791.34, filed on 10/12/1999, (14) U.S. provisional patent application serial no. 60/159,039, attorney docket no. 25791.36, filed on 10/12/1999, (15) U.S. provisional patent application serial no. 60/159,033, attorney docket no. 25791.37, filed on 10/12/1999, (16) U.S. provisional patent application serial no. 60/212,359, attorney docket no. 25791.38, filed on 6/19/2000, (17) U.S. provisional patent application serial no. 60/165,228, attorney docket no. 25791.39, filed on 11/12/1999, (18) U.S. provisional patent application serial no. 60/221,443, attorney docket no. 25791.45, filed on 7/28/2000, (19) U.S. provisional patent application serial no. 60/221,645, attorney docket no. 25791.46, filed on 7/28/2000, (20) U.S. provisional patent application serial no. 60/233,638, attorney docket no. 25791.47, filed on 9/18/2000, (21) U.S. provisional patent application serial no. 60/237,334, attorney docket no. 25791.48, filed on 10/2/2000, (22) U.S. provisional patent application serial no. 60/270,007, attorney docket no. 25791.50, filed on 2/20/2001, (23) U.S. provisional patent application serial no. 60/262,434, attorney docket no. 25791.51, filed on 1/17/2001, (24) U.S, provisional patent application serial no. 60/259,486, attorney docket no. 25791.52, filed on 1/3/2001, (25) U.S. provisional patent application serial no. 60/303,740, attorney docket no. 25791.61, filed on 7/6/2001, (26) U.S. provisional patent application serial no. 60/313,453, attorney docket no. 25791.59, filed on 8/20/2001, (27) U.S. provisional patent application serial no. 60/317,985, attorney docket no. 25791.67, filed on 9/6/2001, (28) U.S. provisional patent application serial no. 60/3318,386, attorney docket no. 25791.67.02, filed on 9/10/2001, (29) U.S. utility patent application serial no. 09/969,922, attorney docket no. 25791.69, filed on 10/3/2001, (30) U.S. utility patent application serial no. 10/016,467, attorney docket no. 25791.70, filed on 12/10/2001, (31) U.S. provisional patent application serial no. 60/343,674, attorney docket no. 25791.68, filed on 12/27/2001, (32) U.S. provisional patent application serial no. 60/346,309, attorney docket no

25791.92, filed on 1/7/2002, (33) U.S. provisional patent application serial no. 60/372,048, attorney docket no. 25791.93, filed on 4/12/2002, (34) U.S. provisional patent application serial no. 60/380,147, attorney docket no. 25791.104, filed on 5/6/2002, (35) U.S. provisional patent application serial no. 60/387,486, attorney docket no. 25791.107, filed on 6/10/2002, (36) U.S. provisional patent application serial no. 60/387,961, attorney docket no. 25791.108, filed on 6/12/2002, (37) U.S. provisional patent application serial no. 60/394,703, attorney docket no. 25791.90, filed on 6/26/2002, (38) U.S. provisional patent application serial no. 60/397,284, attorney docket no. 25791.106, filed on 7/19/2002, (39) U.S. provisional patent application serial no. 60/398,061, attorney docket no. 25791.110, filed on 7/24/2002, (40) U.S. provisional patent application serial no, 60/405,610, attorney docket no. 25791.119, filed on 8/23/2002, (41) U.S. provisional patent application serial no. 60/405,394, attorney docket no. 25791.120, filed on 8/23/2002, (42) U.S. provisional patent application serial no. 60/412,177, attorney docket no. 25791.117, filed on 9/20/2002, (43) U.S. provisional patent application serial no. 60/412,653, attorney docket no. 25791.118, filed on 9/20/2002, (44) U.S. provisional patent application serial no. 60/412,544, attorney docket no. 25791.121, filed on 9/20/2002, (45) U.S. provisional patent application serial no. 60/412,187, attorney docket no. 25791.128, filed on 9/20/2002, (46) U.S. provisional patent application serial no. 60/412,196, attorney docket no. 25791.127, filed on 9/20/2002, (47) U.S. provisional patent application serial no. 60/412,542, attorney docket no. 25791.102, filed on 9/20/2002, (48) U.S. provisional patent application serial no. 60/412,487, attorney docket no. 25791.112, filed on 9/20/2002, (49) U.S. provisional patent application no. 60/412,488, attorney docket no. 25791.114, filed on 9/20/2002, the disclosures of which are incorporated herein by reference.

Background of the Invention

[004] This invention relates generally to oil and gas exploration, and in particular to forming and repairing wellbore casings to facilitate oil and gas exploration.

[005] Conventionally, when a wellbore is created, a number of casings are installed in the borehole to prevent collapse of the borehole wall and to prevent undesired outflow of drilling fluid into the formation or inflow of fluid from the formation into the borehole. The borehole is drilled in intervals whereby a casing which is to be installed in a lower borehole interval is lowered through a previously installed casing of an upper borehole interval. As a consequence of this procedure the casing of the lower interval is of smaller diameter than the casing of the upper interval. Thus, the casings are in a nested arrangement with casing diameters decreasing in downward direction. Cement annuli are provided between the outer surfaces of the casings and the borehole wall to seal the casings from the borehole wall. As a consequence of this nested arrangement a relatively large borehole diameter is required at the upper part of the wellbore. Such a large borehole diameter involves increased costs due to heavy casing handling equipment, large drill bits and increased volumes of drilling fluid and drill

cuttings. Moreover, increased drilling rig time is involved due to required cement pumping, cement hardening, required equipment changes due to large variations in hole diameters drilled in the course of the well, and the large volume of cuttings drilled and removed.

[006] During oil exploration, a wellbore typically traverses a number of zones within a subterranean formation. Wellbore casings are then formed in the wellbore by radially expanding and plastically deforming tubular members that are coupled to one another by threaded connections existing methods for radially expanding and plastically deforming tubular members coupled to one another by threaded connections are not always reliable and do not always produce satisfactory results. In particular, the threaded connections can be damaged during the radial expansion process. Furthermore, the threaded connections between adjacent tubular members, whether radially expanded or not, are typically not sufficiently coupled to permit the transmission of energy through the tubular members from the surface to the downhole location. Further, the damaged threads may permit undesirable leakage between the inside of the casing and the exterior of the casing.

[007] The present invention is directed to overcoming one or more of the limitations of the existing procedures for forming and/or repairing wellbore casings.

Summary of the Invention

[008] According to one aspect of the present invention, an assembly is provided that includes a first tubular member including external threads, and a second tubular member comprising internal threads coupled to the external threads of the first tubular member. At least one of the first and second tubular members define one or more stress concentrators. According to another aspect of the present invention, a method for forming a wellbore casing has been described that includes positioning any one, portion, or combination, of the exemplary embodiments of the assemblies of the present application within a borehole that traverses a subterranean formation, and radially expanding and plastically deforming the assembly within the borehole.

[009] According to another aspect of the present invention, an apparatus is provided that includes a wellbore that traverses a subterranean formation, and a wellbore casing positioned within and coupled to the wellbore. The wellbore casing is coupled to the wellbore by a process including: positioning any one, portion, or combination, of the exemplary assemblies of the present application within the wellbore, and radially expanding and plastically deforming the assembly within the wellbore.

[0010] According to another aspect of the present invention, a system for forming a wellbore casing is provided that includes means for positioning any one, portion, or combination, of the exemplary assemblies of the present application within a borehole that traverses a subterranean formation, and means for radially expanding and plastically deforming the assembly within the borehole.

[0011] According to another aspect of the present invention, a method of providing a fluid tight seal between a pair of overlapping tubular members is provided that includes forming one or more stress

concentrators within at least one of the tubular members, and radially expanding and plastically deforming the tubular members.

[0012] According to another aspect of the present invention, a method for manufacturing an expandable member used to complete a structure by radially expanding and plastically deforming the expandable member is provided that includes forming the expandable member from a steel alloy comprising a charpy energy of at least about 90 ft-lbs.

[0013] According to another aspect of the present invention, an expandable member for use in completing a structure by radially expanding and plastically deforming the expandable member is provided that includes a steel alloy comprising a charpy energy of at least about 90 ft-lbs.

[0014] According to another aspect of the present invention, a structural completion positioned within a structure is provided that includes one or more radially expanded and plastically deformed expandable members positioned within the structure; wherein one or more of the radially expanded and plastically deformed expandable members are fabricated from a steel alloy comprising a charpy energy of at least about 90 ft-lbs.

[0015] According to another aspect of the present invention, a method for manufacturing an expandable member used to complete a structure by radially expanding and plastically deforming the expandable member is provided that includes forming the expandable member from a steel alloy comprising a weight percentage of carbon of less than about 0.08%.

[0016] According to another aspect of the present invention, an expandable member for use in completing a wellbore by radially expanding and plastically deforming the expandable member at a downhole location in the wellbore is provided that includes a steel alloy comprising a weight percentage of carbon of less than about 0.08%.

[0017] According to another aspect of the present invention, a structural completion is provided that includes one or more radially expanded and plastically deformed expandable members positioned within the wellbore; wherein one or more of the radially expanded and plastically deformed expandable members are fabricated from a steel alloy comprising a weight percentage of carbon of less than about 0.08%.

[0018] According to another aspect of the present invention, a method for manufacturing an expandable member used to complete a structure by radially expanding and plastically deforming the expandable member is provided that includes forming the expandable member from a steel alloy comprising a weight percentage of carbon of less than about 0.20% and a charpy V-notch impact toughness of at least about 6 joules.

[0019] According to another aspect of the present invention, an expandable member for use in completing a structure by radially expanding and plastically deforming the expandable member is

provided that includes a steel alloy comprising a weight percentage of carbon of less than about 0.20% and a charpy V-notch impact toughness of at least about 6 joules.

[0020] According to another aspect of the present invention, a structural completion is provided that includes one or more radially expanded and plastically deformed expandable members; wherein one or more of the radially expanded and plastically deformed expandable members are fabricated from a steel alloy comprising a weight percentage of carbon of less than about 0.20% and a charpy V-notch impact toughness of at least about 6 joules.

[0021] According to another aspect of the present invention, a method for manufacturing an expandable member used to complete a structure by radially expanding and plastically deforming the expandable member is provided that includes forming the expandable member from a steel alloy comprising the following ranges of weight percentages: C, from about 0.002 to about 0.08; Si, from about 0.009 to about 0.30; Mn, from about 0.10 to about 1.92; P, from about 0.004 to about 0.07; S, from about 0.0008 to about 0.006; Al, up to about 0.04; N, up to about 0.01; Cu, up to about 0.3; Cr, up to about 0.5; Ni, up to about 18; Nb, up to about 0.12; Ti, up to about 0.6; Co, up to about 9; and Mo, up to about 5.

[0022] According to another aspect of the present invention, an expandable member for use in completing a structure by radially expanding and plastically deforming the expandable member is provided that includes a steel alloy comprising the following ranges of weight percentages: C, from about 0.002 to about 0.08; Si, from about 0.009 to about 0.30; Mn, from about 0.10 to about 1.92; P, from about 0.004 to about 0.07; S, from about 0.0008 to about 0.006; Al, up to about 0.04; N, up to about 0.01; Cu, up to about 0.3; Cr, up to about 0.5; Ni, up to about 18; Nb, up to about 0.12; Ti, up to about 0.6; Co, up to about 9; and Mo, up to about 5.

[0023] According to another aspect of the present invention, a structural completion is provided that includes one or more radially expanded and plastically deformed expandable members; wherein one or more of the radially expanded and plastically deformed expandable members are fabricated from a steel alloy comprising the following ranges of weight percentages: C, from about 0.002 to about 0.08; Si, from about 0.009 to about 0.30; Mn, from about 0.10 to about 1.92; P, from about 0.004 to about 0.07; S, from about 0.0008 to about 0.006; Al, up to about 0.04; N, up to about 0.01; Cu, up to about 0.3; Cr, up to about 0.5; Ni, up to about 18; Nb, up to about 0.12; Ti, up to about 0.6; Co, up to about 9; and Mo, up to about 5.

[0024] According to another aspect of the present invention, a method for manufacturing an expandable tubular member used to complete a structure by radially expanding and plastically deforming the expandable member is provided that includes forming the expandable tubular member with a ratio of the of an outside diameter of the expandable tubular member to a wall thickness of the expandable tubular member ranging from about 12 to 22.

[0025] According to another aspect of the present invention, an expandable member for use in completing a structure by radially expanding and plastically deforming the expandable member is provided that includes an expandable tubular member with a ratio of the of an outside diameter of the expandable tubular member to a wall thickness of the expandable tubular member ranging from about 12 to 22.

[0026] According to another aspect of the present invention, a structural completion is provided that includes one or more radially expanded and plastically deformed expandable members positioned within the structure; wherein one or more of the radially expanded and plastically deformed expandable members are fabricated from an expandable tubular member with a ratio of the of an outside diameter of the expandable tubular member to a wall thickness of the expandable tubular member ranging from about 12 to 22.

[0027] According to another aspect of the present invention, a method of constructing a structure is provided that includes radially expanding and plastically deforming an expandable member; wherein an outer portion of the wall thickness of the radially expanded and plastically deformed expandable member comprises tensile residual stresses.

[0028] According to another aspect of the present invention, a structural completion is provided that includes one or more radially expanded and plastically deformed expandable members; wherein an outer portion of the wall thickness of one or more of the radially expanded and plastically deformed expandable members comprises tensile residual stresses.

[0029] According to another aspect of the present invention, a method of constructing a structure using an expandable tubular member is provided that includes strain aging the expandable member; and then radially expanding and plastically deforming the expandable member.

[0030] According to another aspect of the present invention, a method for manufacturing a tubular member used to complete a wellbore by radially expanding the tubular member at a downhole location in the wellbore comprising: forming a steel alloy comprising a concentration of carbon between approximately 0.002% and 0.08% by weight of the steel alloy.

Brief Description of the Drawings

[0031] Fig. 1 is a fragmentary cross-sectional illustration of a first tubular threadably coupled to a second tubular.

[0032] Fig. 2 is a fragmentary cross-sectional illustration of a first tubular threadably coupled to a second tubular.

Detailed Description of the Illustrative Embodiments

[0033] Fig. 1 illustrates a first tubular member 10 that defines a passage 10a that includes a pin member 12 that includes stress concentration grooves, 14a and 14b, formed in the internal surface of the pin member, and external threads 16 that engage internal threads 18 of a box member 20 of a

second tubular member 22 that defines a passage 22a. Stress concentration grooves, 24a and 24b, are formed in the external surface of the box member 20 of the second tubular member, and an external sleeve 26 is coupled to and overlaps with the ends of the first and second tubular members, 10 and 22. The first tubular member 10, the second tubular member 22, and the external sleeve 26 may be radially expanded and plastically deformed using any number of conventional methods and apparatus and/or as disclosed in one or more of the following: (1) U.S. patent application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, (2) U.S. patent application serial no. 09/510,913, attorney docket no. 25791.7.02, filed on 2/23/2000, (3) U.S. patent application serial no. 09/502,350, attorney docket no. 25791.8.02, filed on 2/10/2000, (4) U.S. patent no. 6,328,113, (5) U.S. patent application serial no. 09/523,460, attorney docket no. 25791.11.02, filed on 3/10/2000, (6) U.S. patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, (7) U.S. patent application serial no. 09/511,941, attorney docket no. 25791.16.02, filed on 2/24/2000, (8) U.S. patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, (9) U.S. patent application serial no. 09/559,122, attorney docket no. 25791.23.02, filed on 4/26/2000, (10) PCT patent application serial no. PCT/US00/18635, attorney docket no. 25791.25.02, filed on 7/9/2000, (11) U.S. provisional patent application serial no. 60/162,671, attorney docket no. 25791.27, filed on 11/1/1999, (12) U.S. provisional patent application serial no. 60/154,047, attorney docket no. 25791.29, filed on 9/16/1999, (13) U.S. provisional patent application serial no. 60/159,082, attorney docket no. 25791.34, filed on 10/12/1999, (14) U.S. provisional patent application serial no. 60/159,039, attorney docket no. 25791.36, filed on 10/12/1999, (15) U.S. provisional patent application serial no. 60/159,033, attorney docket no. 25791.37, filed on 10/12/1999, (16) U.S. provisional patent application serial no. 60/212,359, attorney docket no. 25791.38, filed on 6/19/2000, (17) U.S. provisional patent application serial no. 60/165,228, attorney docket no. 25791.39, filed on 11/12/1999, (18) U.S. provisional patent application serial no. 60/221,443, attorney docket no. 25791.45, filed on 7/28/2000, (19) U.S. provisional patent application serial no. 60/221,645, attorney docket no. 25791.46, filed on 7/28/2000, (20) U.S. provisional patent application serial no. 60/233,638, attorney docket no. 25791.47, filed on 9/18/2000, (21) U.S. provisional patent application serial no. 60/237,334, attorney docket no. 25791.48, filed on 10/2/2000, (22) U.S. provisional patent application serial no. 60/270,007, attorney docket no. 25791.50, filed on 2/20/2001, (23) U.S. provisional patent application serial no. 60/262,434, attorney docket no. 25791.51, filed on 1/17/2001, (24) U.S, provisional patent application serial no. 60/259,486, attorney docket no. 25791.52, filed on 1/3/2001, (25) U.S. provisional patent application serial no. 60/303,740, attorney docket no. 25791.61, filed on 7/6/2001, (26) U.S. provisional patent application serial no. 60/313,453, attorney docket no. 25791.59, filed on 8/20/2001, (27) U.S. provisional patent application serial no. 60/317,985, attorney docket no. 25791.67, filed on 9/6/2001, (28) U.S. provisional patent application serial no.

60/3318,386, attorney docket no. 25791.67.02, filed on 9/10/2001, (29) U.S. utility patent application serial no. 09/969,922, attorney docket no. 25791.69, filed on 10/3/2001, (30) U.S. utility patent application serial no. 10/016,467, attorney docket no. 25791.70, filed on 12/10/2001, (31) U.S. provisional patent application serial no. 60/343,674, attorney docket no. 25791.68, filed on 12/27/2001, (32) U.S. provisional patent application serial no. 60/346,309, attorney docket no 25791.92, filed on 1/7/2002, (33) U.S. provisional patent application serial no. 60/372,048, attorney docket no. 25791.93, filed on 4/12/2002, (34) U.S. provisional patent application serial no. 60/380,147, attorney docket no. 25791.104, filed on 5/6/2002, (35) U.S. provisional patent application serial no. 60/387,486, attorney docket no. 25791.107, filed on 6/10/2002, (36) U.S. provisional patent application serial no. 60/387,961, attorney docket no. 25791.108, filed on 6/12/2002, (37) U.S. provisional patent application serial no. 60/394,703, attorney docket no. 25791.90, filed on 6/26/2002, (38) U.S. provisional patent application serial no. 60/397,284, attorney docket no. 25791.106, filed on 7/19/2002, (39) U.S. provisional patent application serial no. 60/398,061, attorney docket no. 25791.110, filed on 7/24/2002, (40) U.S. provisional patent application serial no, 60/405,610, attorney docket no. 25791.119, filed on 8/23/2002, (41) U.S. provisional patent application serial no. 60/405,394, attorney docket no. 25791.120, filed on 8/23/2002, (42) U.S. provisional patent application serial no. 60/412,177, attorney docket no. 25791.117, filed on 9/20/2002, (43) U.S. provisional patent application serial no. 60/412,653, attorney docket no. 25791.118, filed on 9/20/2002, (44) U.S. provisional patent application serial no. 60/412,544, attorney docket no. 25791.121, filed on 9/20/2002, (45) U.S. provisional patent application serial no. 60/412,187, attorney docket no. 25791.128, filed on 9/20/2002, (46) U.S. provisional patent application serial no. 60/412,196, attorney docket no. 25791.127, filed on 9/20/2002, (47) U.S. provisional patent application serial no. 60/412,542, attorney docket no. 25791.102, filed on 9/20/2002, (48) U.S. provisional patent application serial no. 60/412,487, attorney docket no. 25791.112, filed on 9/20/2002, (49) U.S. provisional patent application no. 60/412,488, attorney docket no. 25791.114, filed on 9/20/2002, the disclosures of which are incorporated herein by reference.

[0034] In an exemplary embodiment, during the radial expansion and plastic deformation of the first tubular member 10, the second tubular member 22, and the external sleeve 26, the stress concentration grooves, 14a, 14b, 24a, and 24b, concentrate compressive stresses onto the threads, 16 and 18, of the pin and box members, 12 and 20, of the first and second tubular members to drive the threads together to thereby provide a fluid tight seal between the threads of the pin and box members of the first and second tubular members upon the completion of the radial expansion and plastic deformation.

[0035] Fig. 2 is an illustration of another illustrative embodiment.

[0036] In an exemplary embodiment, a tribological system is used to reduce friction and thereby

minimize the expansion forces required during the radial expansion and plastic deformation of the tubular members that includes one or more of the following: (1) a tubular tribology system; (2) a drilling mud tribology system; (3) a lubrication tribology system; and (4) an expansion device tribology system.

[0037] In an exemplary embodiment, the tubular tribology system includes the application of coatings of lubricant to the interior surface of the tubular members.

[0038] In an exemplary embodiment, the drilling mud tribology system includes the addition of lubricating additives to the drilling mud.

[0039] In an exemplary embodiment, the lubrication tribology system includes the use of lubricating greases, self-lubricating expansion devices, automated injection/delivery of lubricating greases into the interface between an expansion device and the tubular members, surfaces within the interface between the expansion device and the expandable tubular member that are self-lubricating, surfaces within the interface between the expansion device and the expandable tubular member that are textured, self-lubricating surfaces within the interface between the expansion device and the expandable tubular member that include diamond and/or ceramic inserts, thermosprayed coatings, fluoropolymer coatings, PVD films, and/or CVD films.

[0040] In an exemplary embodiment, the tubular members include one or more of the following characteristics: high burst and collapse, the ability to be radially expanded more than about 40%, high fracture toughness, defect tolerance, strain recovery @ 150 F, good bending fatigue, optimal residual stresses, and corrosion resistance to H_2S in order to provide optimal characteristics during and after radial expansion and plastic deformation.

[0041] In an exemplary embodiment, the tubular members are fabricated from a steel alloy having a charpy energy of at least about 90 ft-lbs in order to provided enhanced characteristics during and after radial expansion and plastic deformation of the expandable tubular member.

[0042] In an exemplary embodiment, the tubular members are fabricated from a steel alloy having a weight percentage of carbon of less than about 0.08% in order to provide enhanced characteristics during and after radial expansion and plastic deformation of the tubular members.

[0043] In an exemplary embodiment, the tubular members are fabricated from a steel alloy having reduced sulfur content in order to minimize hydrogen induced cracking.

[0044] In an exemplary embodiment, the tubular members are fabricated from a steel alloy having a weight percentage of carbon of less than about 0.20 % and a charpy-V-notch impact toughness of at least about 6 joules in order to provide enhanced characteristics during and after radial expansion and plastic deformation of the tubular members.

[0045] In an exemplary embodiment, the tubular members are fabricated from a steel alloy having a low weight percentage of carbon in order to enhance toughness, ductility, weldability, shelf energy, and hydrogen induced cracking resistance.

[0046] In several exemplary embodiments, the tubular members are fabricated from a steel alloy having the following percentage compositions in order to provide enhanced characteristics during and after radial expansion and plastic deformation of the tubular members:

	C	Si	Mn	P	S	Al	N	Cu	Cr	Ni	Nb	Ti	Co	Mo
Example A	0.030	0.22	1.74	0.005	0.0005	0.028	0.0037	0.30	0.26	0.15	0.095	0.014	0.0034	
Example B Min	0.020	0.23	1.70	0.004	0.0005	0.026	0.0030	0.27	0.26	0.16	0.096	0.012	0.0021	
Example B Max	0.032	0.26	1.92	0.009	0.0010	0.035	0.0047	0.32	0.29	0.18	0.120	0.016	0.0050	
Example C	0.028	0.24	1.77	0.007	0.0008	0.030	0.0035	0.29	0.27	0.17	0.101	0.014	0.0028	0.0020
Example D	0.08	0.30	0.5	0.07	0.005		0.010	0.10	0.50	0.10				
Example E	0.0028	0.009	0.17	0.011	0.006	0.027	0.0029		0.029	0.014	0.035	0.007		
Example F	0.03	0.1	0.1	0.015	0.005					18.0		0.6	9	5
Example G	0.002	0.01	0.15	0.07	0.005	0.04	0.0025				0.015	0.010		

[0047] In an exemplary embodiment, the ratio of the outside diameter D of the tubular members to the wall thickness t of the tubular members range from about 12 to 22 in order to enhance the collapse strength of the radially expanded and plastically deformed tubular members.

[0048] In an exemplary embodiment, the outer portion of the wall thickness of the radially expanded and plastically deformed tubular members includes tensile residual stresses in order to enhance the collapse strength following radial expansion and plastic deformation.

[0049] In several exemplary experimental embodiments, reducing residual stresses in samples of the tubular members prior to radial expansion and plastic deformation increased the collapse strength of the radially expanded and plastically deformed tubular members.

[0050] In several exemplary experimental embodiments, the collapse strength of radially expanded and plastically deformed samples of the tubulars were determined on an as-received basis, after strain aging at 250 F for 5 hours to reduce residual stresses, and after strain aging at 350 F for 14 days to reduce residual stresses as follows:

Tubular Sample	Collapse Strength After 10% Radial Expansion
Tubular Sample 1 – as received from manufacturer	4000 psi
Tubular Sample 1 – strain aged at 250 F for 5 hours to reduce residual stresses	4800 psi
Tubular Sample 1 – strain aged at 350 F for 14 days to reduce residual stresses	5000 psi

[0051] As indicated by the above table, reducing residual stresses in the tubular members, prior to radial expansion and plastic deformation, significantly increased the resulting collapse strength – post expansion.

[0052] An assembly has been described that includes a first tubular member including external threads, and a second tubular member comprising internal threads coupled to the external threads of the first tubular member. At least one of the first and second tubular members define one or more stress concentrators. In an exemplary embodiment, the assembly further comprises an external sleeve coupled to and overlapping with the ends of the first and second tubular members. In an exemplary embodiment, one or more of the stress concentrators comprise surface grooves formed in the surfaces of at least one of the first and second tubular members. In an exemplary embodiment, the stress concentrators are defined above the internal and external threads of the first and second tubular members.

[0053] A method for forming a wellbore casing has been described that includes positioning any one, portion, or combination, of the exemplary embodiments of the assemblies of the present application within a borehole that traverses a subterranean formation, and radially expanding and plastically deforming the assembly within the borehole.

[0054] An apparatus has been described that includes a wellbore that traverses a subterranean formation, and a wellbore casing positioned within and coupled to the wellbore. The wellbore casing is coupled to the wellbore by a process including: positioning any one, portion, or combination, of the exemplary assemblies of the present application within the wellbore, and radially expanding and plastically deforming the assembly within the wellbore.

[0055] A system for forming a wellbore casing has been described that includes means for positioning any one, portion, or combination, of the exemplary assemblies of the present application within a borehole that traverses a subterranean formation, and means for radially expanding and plastically deforming the assembly within the borehole.

[0056] A method of providing a fluid tight seal between a pair of overlapping tubular members has been described that includes forming one or more stress concentrators within at least one of the tubular members, and radially expanding and plastically deforming the tubular members. In an exemplary embodiment, the tubular members are threadably coupled, and the stress concentrators are formed above the threaded coupling.

[0057] In an exemplary embodiment, the stress concentrators comprise surface grooves formed in at least one of the tubular members.

[0058] A method for manufacturing an expandable member used to complete a structure by radially expanding and plastically deforming the expandable member has been described that includes

forming the expandable member from a steel alloy comprising a charpy energy of at least about 90 ft-lbs.

[0059] An expandable member for use in completing a structure by radially expanding and plastically deforming the expandable member has been described that includes a steel alloy comprising a charpy energy of at least about 90 ft-lbs.

[0060] A structural completion positioned within a structure has been described that includes one or more radially expanded and plastically deformed expandable members positioned within the structure; wherein one or more of the radially expanded and plastically deformed expandable members are fabricated from a steel alloy comprising a charpy energy of at least about 90 ft-lbs.

[0061] A method for manufacturing an expandable member used to complete a structure by radially expanding and plastically deforming the expandable member has been described that includes forming the expandable member from a steel alloy comprising a weight percentage of carbon of less than about 0.08%.

[0062] An expandable member for use in completing a wellbore by radially expanding and plastically deforming the expandable member at a downhole location in the wellbore has been described that includes a steel alloy comprising a weight percentage of carbon of less than about 0.08%.

[0063] A structural completion has been described that includes one or more radially expanded and plastically deformed expandable members positioned within the wellbore; wherein one or more of the radially expanded and plastically deformed expandable members are fabricated from a steel alloy comprising a weight percentage of carbon of less than about 0.08%.

[0064] A method for manufacturing an expandable member used to complete a structure by radially expanding and plastically deforming the expandable member has been described that includes forming the expandable member from a steel alloy comprising a weight percentage of carbon of less than about 0.20% and a charpy V-notch impact toughness of at least about 6 joules.

[0065] An expandable member for use in completing a structure by radially expanding and plastically deforming the expandable member has been described that includes a steel alloy comprising a weight percentage of carbon of less than about 0.20% and a charpy V-notch impact toughness of at least about 6 joules.

[0066] A structural completion has been described that includes one or more radially expanded and plastically deformed expandable members; wherein one or more of the radially expanded and plastically deformed expandable members are fabricated from a steel alloy comprising a weight percentage of carbon of less than about 0.20% and a charpy V-notch impact toughness of at least about 6 joules.

[0067] A method for manufacturing an expandable member used to complete a structure by radially expanding and plastically deforming the expandable member has been described that includes

forming the expandable member from a steel alloy comprising the following ranges of weight percentages: C, from about 0.002 to about 0.08; Si, from about 0.009 to about 0.30; Mn, from about 0.10 to about 1.92; P, from about 0.004 to about 0.07; S, from about 0.0008 to about 0.006; Al, up to about 0.04; N, up to about 0.01; Cu, up to about 0.3; Cr, up to about 0.5; Ni, up to about 18; Nb, up to about 0.12; Ti, up to about 0.6; Co, up to about 9; and Mb, up to about 5.

[0068] An expandable member for use in completing a structure by radially expanding and plastically deforming the expandable member has been described that includes a steel alloy comprising the following ranges of weight percentages: C, from about 0.002 to about 0.08; Si, from about 0.009 to about 0.30; Mn, from about 0.10 to about 1.92; P, from about 0.004 to about 0.07; S, from about 0.0008 to about 0.006; Al, up to about 0.04; N, up to about 0.01; Cu, up to about 0.3; Cr, up to about 0.5; Ni, up to about 18; Nb, up to about 0.12; Ti, up to about 0.6; Co, up to about 9; and Mo, up to about 5.

[0069] A structural completion has been described that includes one or more radially expanded and plastically deformed expandable members; wherein one or more of the radially expanded and plastically deformed expandable members are fabricated from a steel alloy comprising the following ranges of weight percentages: C, from about 0.002 to about 0.08; Si, from about 0.009 to about 0.30; Mn, from about 0.10 to about 1.92; P, from about 0.004 to about 0.07; S, from about 0.0008 to about 0.006; Al, up to about 0.04; N, up to about 0.01; Cu, up to about 0.3; Cr, up to about 0.5; Ni, up to about 18; Nb, up to about 0.12; Ti, up to about 0.6; Co, up to about 9; and Mb, up to about 5.

[0070] A method for manufacturing an expandable tubular member used to complete a structure by radially expanding and plastically deforming the expandable member has been described that includes forming the expandable tubular member with a ratio of the of an outside diameter of the expandable tubular member to a wall thickness of the expandable tubular member ranging from about 12 to 22.

[0071] An expandable member for use in completing a structure by radially expanding and plastically deforming the expandable member has been described that includes an expandable tubular member with a ratio of the of an outside diameter of the expandable tubular member to a wall thickness of the expandable tubular member ranging from about 12 to 22.

[0072] A structural completion has been described that includes one or more radially expanded and plastically deformed expandable members positioned within the structure; wherein one or more of the radially expanded and plastically deformed expandable members are fabricated from an expandable tubular member with a ratio of the of an outside diameter of the expandable tubular member to a wall thickness of the expandable tubular member ranging from about 12 to 22.

[0073] A method of constructing a structure has been described that includes radially expanding and plastically deforming an expandable member; wherein an outer portion of the wall thickness of the radially expanded and plastically deformed expandable member comprises tensile residual stresses.

[0074] A structural completion has been described that includes one or more radially expanded and plastically deformed expandable members; wherein an outer portion of the wall thickness of one or more of the radially expanded and plastically deformed expandable members comprises tensile residual stresses.

[0075] A method of constructing a structure using an expandable tubular member has been described that includes strain aging the expandable member; and then radially expanding and plastically deforming the expandable member.

[0076] A method for manufacturing a tubular member used to complete a wellbore by radially expanding the tubular member at a downhole location in the wellbore has been described that includes forming a steel alloy comprising a concentration of carbon between approximately 0.002% and 0.08% by weight of the steel alloy.

[0077] It is understood that variations may be made in the foregoing without departing from the scope of the invention. For example, the teachings of the present illustrative embodiments may be used to provide a wellbore casing, a pipeline, or a structural support. Furthermore, the elements and teachings of the various illustrative embodiments may be combined in whole or in part in some or all of the illustrative embodiments. In addition, the external sleeve 26 may be omitted. Furthermore, one or more of the stress concentration grooves, 14a, 14b, 24a, and/or 24b, may be omitted. In addition, the stress concentration grooves, 14a, 14b, 24a, and/or 24b may be provided in any geometric shape capable of concentrating stresses. Furthermore, the stress concentration grooves, 14a and 14b, may or may not be positioned in opposing relation to the stress concentration grooves, 24a and 24b. In addition, the first and second tubular members, 10 and 22, may or may not be threadably coupled to one another, and the threads, 16 and 18, of the first and second tubular members may be any type of threads.

[0078] Although illustrative embodiments of the invention have been shown and described, a wide range of modification, changes and substitution is contemplated in the foregoing disclosure. In some instances, some features of the present invention may be employed without a corresponding use of the other features. Accordingly, it is appropriate that the appended claims be construed broadly and in a manner consistent with the scope of the invention.